Overall learning objectives	Overall learning outcomes
• Understanding how systems are developed to meet certain requirements. • Applying ideas about waves such as light and X-rays to develop solutions to problems. • Using logical reasoning to analyse the outcomes from a process.	• Being able to explain how and why systems are designed in certain ways. • Applying scientific concepts such as the properties of light and X-rays. • Logically deducing the range of outputs from a system.

Curriculum learning objectives

Students should be able to:

Maths

- Apply suitable mathematics accurately within the classroom and beyond.
- Use existing mathematical knowledge to create solutions to unfamiliar problems.
- Work logically towards results and solutions, recognising the impact of constraints and assumptions.

Science

- Explore how the creative application of scientific ideas can bring about technological developments and consequent changes in the way people think and behave.
- Critically analyse and evaluate evidence from observations and experiments.

Technology

- Explore how products have been designed and made in the past, how they are currently designed and made, and how they may develop in the future.
- Make links between principles of good design, existing solutions and technological knowledge to develop innovative products and processes.

Episode 1

The Challenge

In this episode students are introduced to the context of a baggage handling system in a modern airport. They will be designing a city centre baggage drop facility that enables travellers to deposit luggage upon checking out from their hotel but before leaving for the airport. Students are presented with the idea of Heathrow adopting a similar system, but with items having to be coded with the correct terminal. The challenge will be to devise and test a coding system.

Learning objectives

- Understand the characteristics of a system.
- Clarify the nature of the problem to be solved.

Additional resources required:

- LDR 12
- Black paper
- Light paper
- Kitchen / toilet roll tube

Learning activities

1. **Show the video clip which presents the importance of a baggage handling system being both rapid and precise in terms of getting the right bag to the right place.**

2. **Ask the students who have experienced baggage handling facilities at airports, if this has been their experience.**

3. **Present students with the situation and the solution. Explain that passengers are to be provided with a city centre baggage drop facility that means that their luggage can be deposited in the city, leaving them free to do other things and follow on afterwards. Use slide 5 to present this. Then show slide 6 to explain the problem the airport now has in sorting luggage so that it goes to the right terminal.**

4. **Explain that the airport wants to avoid manual sorting because it is expensive and slow. Handlers would have to read each label to see which flight the case was destined for, sort out which terminal that flight went from and group the cases accordingly. The airport wants a system that works automatically, with luggage being recognised and routed to the correct terminal. Their plan is that when the luggage is checked in, passengers are given a sticker to attach to each case, showing which terminal. The challenge is for the system to read the sticker.**

5. **Ask students questions to clarify that they understand the nature of the challenge.**

Outcomes

- Students to be clear about the nature of the challenge and to be able to describe it in their own words.

Episode 2

Investigate

Students investigate how a simple detector can distinguish between light and dark surfaces and consider how this could be used as part of an optical recognition system. They will investigate how a light dependent resistor (LDR) can detect the amount of light reflected from a printed surface and thus detect light or dark squares.

Learning objectives

- Explain how light levels can be measured.
- Apply this to recognising differences in the reflection from pale and dark paper.
- Develop a plan for a device which would reliably indicate whether a surface was light or dark.

Learning activities

1. **Explain to students that a key part of the design system will be the ability to recognise the difference between light and dark surfaces. This will enable an optical recognition system to be devised. Show the students (or remind them) an ORP (OPR) 12 LDR (Light Dependant Resistor) and explain that its resistance changes according to the amount of light. Show how a multi-meter can be switched to a resistance range and connected to the ORP12.**

2. **Ask students to work in groups to investigate how the resistance of an ORP12 alters in varying amounts of light. Take feedback and draw out the point that its resistance increases if there is less light.** *(Technical note: the leads on ORP12s won't take too much stress. It's a good idea to have them mounted on pieces of circuit board with terminals; this will greatly extend their working life).*

3. **Now ask students to use the equipment to see if it will detect the difference between light reflected from a dark surface (such as black paper) and a light surface (white paper). Ask students to take readings. Gather some of the readings and ask why readings for the same surface vary. Draw out that it's affected by factors such as distance from the surface and the amount of light in the room.**

4. **Ask how well it would work to mount the LDR in a tube. (You might have one mounted in the end of a toilet roll tube). Draw out that, whereas this would address the issues of distance and extraneous light, it might cut down the light too much. Suggest a bulb going in the tube as well; from the discussion draw out that the device needs to be gathering reflected light. Ask students to work in groups to draw a simple diagram showing how light from a source (such as a bulb) needs to be reflected by a surface (the white or black paper) into the detector.**

5. **Then ask students to sketch a design that would do this. It should eliminate (to a reasonable degree) extraneous light, provide its own light and allow the detector to gather reflected light. Share ideas and take feedback.**

Outcomes

- Students showing that they can use the equipment effectively and explain how and why they are using it.
- Students developing ideas for a design that satisfies various requirements.

Episode 3

Investigate

Students consider how a coding system could be devised to represent a range of destinations. They will explore how a sequence of light and dark squares could represent one of the five terminals and design a code accordingly.

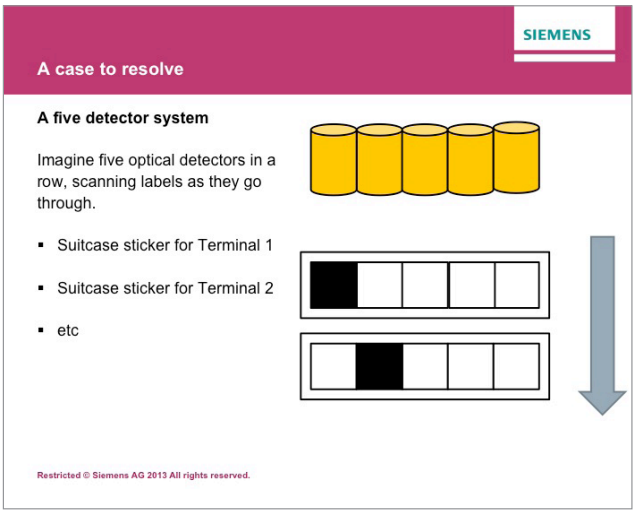
Note: it is possible to use this to teach or reinforce teaching about binary notation as the blacks and whites can be represented by 1s and 0s.

Learning objectives

- Identify factors in the design of a system.
- Apply logical reasoning to evaluate a system.

Learning activities

1. **Remind students of the outcomes of the previous episode as appropriate and of the design for a detector which could tell the difference between a light and a dark area. Explain that the next step is to design a system that uses a number of these detectors to decode a luggage sticker.**



2. **Show slide 8 and explain that one system (for a five terminal airport) would be to have five squares, and to have a different one blacked to denote the terminal. Explain that this would work and that being a simple system it's easy to understand. However, it has disadvantages. Ask students to work in groups to answer these questions and present responses:**
   a) What happens if a Terminal 1 sticker is put on or read the wrong way round?
   b) What happens if the airport opens a sixth terminal?
   c) What happens if the cost of five detectors in every unit pushes the cost up to the point that your system is more expensive than that of your competitors?
3. **Take feedback and draw out these points:**
   a) Having labels that are misleading if reversed is not a good idea.
   b) Good systems should have capacity for expansion.
   c) The idea of units with fewer detectors could be explored.

Outcomes

- Students are able to explore a system and evaluate its features, including if the demands upon it changed.

Episode 4

Solutions

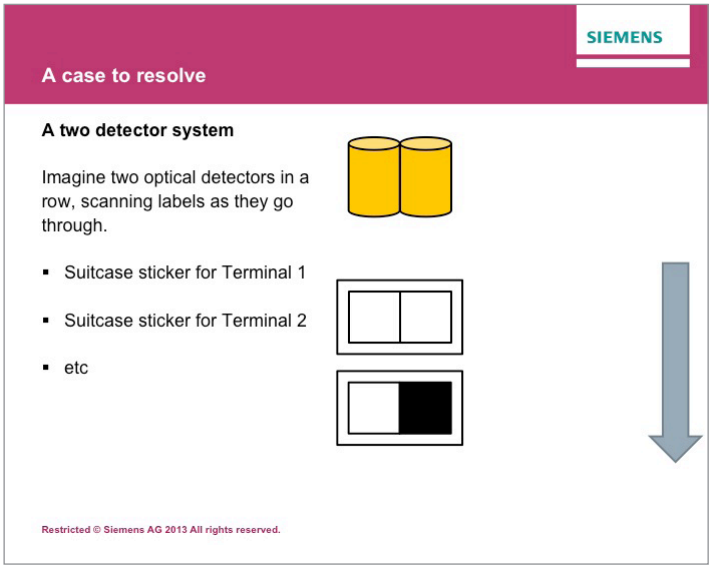
Students consider wider design constraints such as allowing for future expansion of the system and possible problems through incorrect use. This would include finding out, for example, if a sixth terminal was built how easily the system could be adopted and whether reading the code the wrong way round could lead to problems.

Learning objectives

- Design a system to allow for various factors.
- Apply logical reasoning to evaluate a system.

Learning activities

1. **Remind students of the outcomes of the previous episode as appropriate and the key points about problems with labels that can be misread, systems being capable of expansion and avoiding unnecessary expense in systems.**



2. **Show slide 9 and explain that this would work for a two terminal system. Then show slide 10 and ask students to work out how many terminals a two detector unit would be able to code for. Then ask students to find out if any of these could be reversed to give a wrong response. Draw out that it would work for four terminals but that two of these could be reversed to give incorrect responses.**

3. **Now show slide 11 and ask students to investigate how well a three detector system would work. They should determine:**
   a) How many terminals this system could code for.
   b) Whether any of the labels could be reversed to give an incorrect response.
   c) Whether they would recommend this for a five terminal airport and why.

4. **Take feedback and draw out that there are eight different labels but that there are two 'reversible pairs' (BBW/WBB and WWB/BWW) so it could code safely for six terminals, giving a spare capacity of one. Consider students' arguments as to whether this is sufficient capacity.**

Outcomes

- Students are able to evaluate a system and decide if it is fit for purpose.

Episode 5

Evaluate

Students are then introduced to other aspects of baggage handling systems and consider the reasons for various features.

Learning objectives

- Understand how a system works and identify key features.
- Understand how X-rays are used in a security system, how images are formed by them and how these can be interpreted.

Learning activities

1. **Explain to students that baggage handling systems don't only have to be able to sort baggage out for different destinations. Show students video on SiBag system and ask them, as they watch this, to make a note of various features that a handling system has to have. Explain that this system is a more conventional one than the city centre drop in one. It is taking baggage from the check in counter in the airport and transferring it to the point where the handling teams load it onto vehicles to take it to the aircraft.**
2. **Show students slide 12 and ask students to identify various features of the system. If necessary prompt them to recognise where:**
   a) Luggage enters.
   b) Luggage is X-rayed.
   c) Luggage goes onto carousel to be collected by baggage handlers.
3. **Ask pupils to suggest what the purpose of the X-ray machine is and how it works. KS3 pupils will probably not have studied X-rays previously (though they will be familiar with other electromagnetic radiation such as light); this can either be run as direct instruction or a research task. A student briefing sheet is available for use as appropriate. Draw out that X-rays penetrate materials of a lower density but are absorbed by ones of a higher density, thus not passing through to the detector.**
4. **Have a collection of items (ideally a typically packed suitcase) and ask students which objects they think will let X-rays through. Draw out that items such as keys, belt buckles and aerosol cans will absorb X-rays and hence show up (as silhouettes) on the screen.**
5. **Reinforce this by showing students X-ray images of actual suitcases and ask them to see what they can recognise from these. Sample X-rays have been included in the presentation.**

Outcomes

- Students are able to evaluate a system and decide if it is fit for purpose.